(12) UK Patent Application (19) GB (11) 2 083 969 A

(21) Application No 8127965
(22) Date of filing 16 Sep 1981
(30) Priority data
(31) 3035524
(32) 19 Sep 1980
(33) Fed Rep of Germany (DE)
(43) Application published
31 Mar 1982
(51) INT Cl.³
G01N 23/20
(52) Domestic classification
H4F D18K D18X D27M D83B DX H5R 8C
(56) Documents cited
GB 1463054
DE 2461877 A
(58) Field of search
H4F
(71) Applicants
N.V. Philips' Gloeilampenfabrieken,
Pieter Zeemanstraat 6,
NL-5621 CT, Eindhoven,
The Netherlands
(72) Inventors
Geoffrey Harding
Alfred Meyer
(74) Agent
R. J. Boxall,
Mullard House,
Torrington Place, London
WC1E 7HD

(54) **Scatter radiation fluoroscopy apparatus**

(57) The invention relates to an apparatus for determining the internal structure of a body, comprising a radiation source 1 for emitting a primary radiation beam 4 which penetrates the body 6 and which has a substantially point cross-section at at least one location 10 along its path, and a detector/collimator device 9 which detects only radiation which originates from the location of a given point cross-section 10 and which is scattered within a given solid angle 11. The detector device 9 is constructed and arranged so that it provides a discriminative measurement of scatter radiation extending in different directions within the solid angle 11, enabling a shadowgraph image of body structures 7 lying between the virtual point source of radiation, formed by the irradiated region 10, and the detector 8, to be displayed on a monitor 13. Also disclosed are a laminar source with collimator to produce a focussed beam, and an annular collimated laminar focussing source with concentric detector device to detect back-scattered radiation from the point of focus.

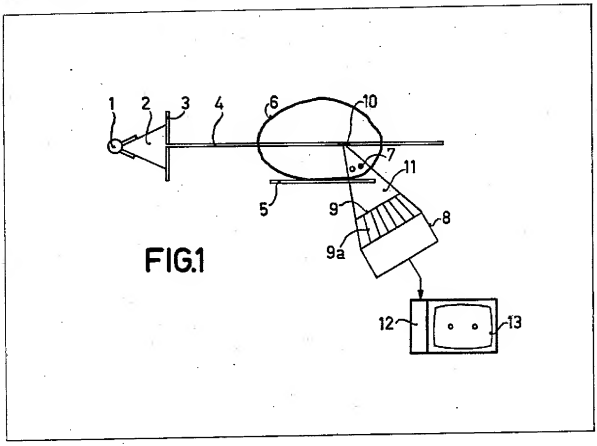

FIG.1

GB 2 083 969 A

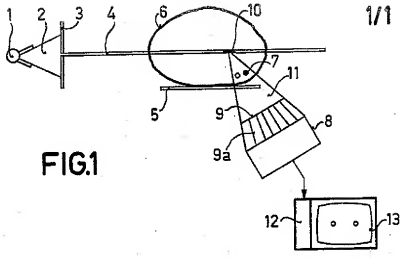

FIG.1

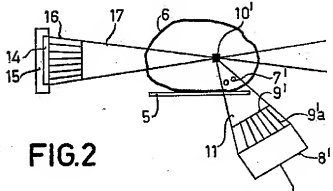

FIG.2

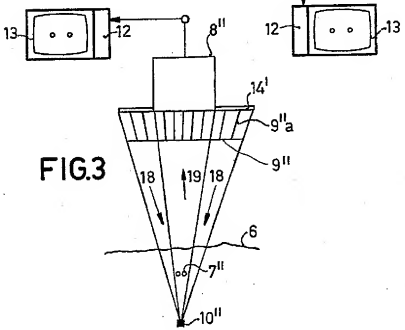

FIG.3

SPECIFICATION

Scatter radiation fluoroscopy apparatus

The invention relates to an apparatus for determining the internal structure of a body, comprising at least one radiation source for emitting a primary radiation beam which penetrates the body and which has a substantially point cross-section at at least one location along its path, and at least one detector/collimator device for selectively detecting that raditlon which originates from the location of the or a predetermined said point cross-section and which is scattered through a given solid angle in a direction which is different from the primary beam direction.

An apparatus of this kind is known from German Offenlegungsschrift 24 61 877. A collimator therein forms a narrow primary beam which passes through the body, whilst a detector which is arranged behind the collimator measures the intensity of the total amount of scatter radiation passing through the collimator in order to determine a separate value which is associated with a relevant point of the body, for example, for the body density at that point. Thus, the detector supplies a detector output signal which relates to only one corresponding body point at a time.

For imaging a larger region of the body, several adjacent body points are considered, and for these points corresponding density values are determined on the basis of the scatter radiation measured on each occasion. To achieve this, the detector/collimator device and the primary beam are displaced relative to the body. Thus, only those body points are considered which are irradiated by the primary beam. Therefore, the apparatus is not suitable for determining the internal structure of body regions which are not irradiated by the primary beam.

It is an object of the invention to provide improved fluoroscopy apparatus which enables, while utilizing scatter radiation, a determination to be made of the internal structure of body regions which are situated outside the path of the primary beam.

According to the invention there is provided an apparatus for determining the internal structure of a body, comprising at least one radiation source for emitting a primary radiation beam which penetrates the body and which has a substantially point cross-section at at least one location along its path, and at least one detector/collimator device for selectively detecting that radiation which originates from the location of the or a predetermined said cross-section and which is scattered through a given solid angle in a direction which is different from the primary beam direction, characterized in that the detector device is constructed and arranged to provide a discriminative detection and measurement of scatter radiation extending in different directions within said solid angle, the arrangement being such that a shadowgraph image of internal structures of the body lying between said location and said detector/collimator device can be derived from the output of said detector device.

To achieve this, the detector device is provided with a sufficient degree of local resolution and with a collimator device so that from a point region, which may be considered as a virtual radiation source in this case the attenuation of the body region situated between said point region and the detector collimator device, can be measured and a shadow image can thereby be formed of that body region. The said point region may be moved to the vicinity of a part of the body to be examined by displacement of the radiation source and the collimator/detector device, so that each time it is only necessary to irradiate a comparatively small part of the body. This is advantageous because this makes it possible in may cases for only those parts of the body which are really important for an examination to be disposed in the path of scatter radiation from the irradiated point region, so that a fluoroscopic image can be obtained from the detector device which is not disturbed by adjacent structural features of the body.

The device is also suitable for testing materials, for example for defects such as air inclusions in, for example, cast aluminium objects. To achieve this, the said point region (herein also referred to as the virtual radiation source) is moved, for example, into the vicinity of regions to be subjected to high mechanical loads, said regions being irradiated by the scatter radiation originating from the said point region. The presence of air inclusions affecting the strength can then be readily observed in the fluoroscopic image.

Embodiments in accordance with the invention will now be described by way of example, with reference to the accompanying drawing, in which:—

Figure 1 shows fluoroscopy apparatus utilizing scatter radiation produced by a narrow pencil beam of primary X-radiation.

Figure 2 shows a fluoroscopy apparatus utilizing scatter radiation produced by a focused beam of gamma radiation, and

Figure 3 shows a fluoroscopy apparatus utilizing back-scattered radiation produced by a combined gamma radiation source and a detector device.

The apparatus shown in Figure 1 comprises an X-ray source 1 whose radiation 2 is limited by means of a diaphragm 3 in order to form a primary X-ray beam 4 having a small cross-section (*i.e.* a pencil beam) which is directed through a body 6, for example, an object to be examined, which is situated on a table 5. For imaging the body structures 7 to be examined or for determining whether certain structures are present within a given body region, for example, air inclusions in a cast object, the body 6 and the X-ray source 1 are displaced relative to each other so that the primary beam 4 extends in the vicinity of the body structures 7 to be examined.

Adjacent the primary beam 4 there is located a detector/collimator device 8, 9 which is arranged to detect substantially only that radiation which originates from a point region of the body 10 situated in the path of the primary beam 4 and which has been scattered within a region represented by a solid angle 11 lying outside the primary beam. To achieve this, the detector device is provided with sufficient local resolution so that thereby scatter radiation

extending in different directions, *i.e.* along different scatter beam paths, within the solid angle region 11, can be discriminatively measured. The detector/collimator device 8, 9 is also arranged to be displaceable with respect to the primary beam 4, so that different respective body regions can be examined.

Thus, using the detector/collimator device 8, 9 shadow images of the body structures 7 to be examined can be obtained, without it being necessary to irradiate large regions of the body. The point regions 10 of the body defined as a result of limitation of radiation by the collimator device 9, may then be considered as a "virtual point-source of radiation". For limiting and selecting radiation from this zone, the collimator device 9 comprises, for example, lead laminations 9a which are situated in planes which intersect one another in a line which extends through the point region 10 of the body transversely (for example at right angles) with respect to the primary radiation direction. The collimator device, however, may alternatively consist of a two-dimensional scatter radiation grid which is focused on the point region and which additionally serves for the suppression of multiple scattering.

The detector device 8 consists of, for example an opto-electronic image converter which comprises an X-ray image intensifier and which is connected to an electronic unit 12 for processing the detector output signals and to a monitor 13 for displaying the shadow-graph images. The detector device 8 may be constructed so that it completely or partly encircles the primary beam 4. It will be apparent that any differences in the intensity of the scatter radiation which are due to the angular dependency of the scattering, can be corrected by means of the electronic unit 12 by a corresponding processing of the detector output signals.

The shadowgraph (fluoroscopy) images can be recorded on a film or can be sensed by means of other suitable forms of detector having local resolution properties, for example, by means of a detector matrix consisting of scintillators or semiconductor detectors.

The radiation source of the apparatus shown in Figure 2 is a flat gamma radiation source 14 which is arranged in a radiation shielding housing 15. In front of the gamma radiation source 15, which consists of, for example, 137 Cs, (662 keV) there is arranged a collimator 16 which passes only the gamma rays 17 emerging from the surface which are directed onto a point region 10' of the body *i.e.* the collimator 16 focuses the gamma rays onto a point-shaped body region 10'. In order to obtain shadowgraph images of the body structures 7' to be examined, a local resolution detector device 8' is arranged to be displaceable relative to the body 6 together with the gamma radiation source 14, in order to change the position of the point-shaped region 10'. It will be apparent that the position of the body 6 can also be changed by corresponding displacements of the table 5 with respect to the radiation source/detector device. The planes in which the collimator laminations 9'a are situated again intersect one another in a common line which extends through the point region 10' transversely of the primary beam direction, for example, at right angles to the symmetry line of the primary radiation beam. Of course, the collimator device 9' may, as before, be constructed as a two-dimensional scatter radiation grid which is focused onto the point-shaped region.

Figure 3 shows a combined radiation source/detector device 14'; 8'' whereby radiation 19 which has been scattered through very large angles with respect to the primary radiation direction 18 can be measured (backward scattering).

The radiation source 14 consist of a radio-active material, for example, 137 Cs (662 KeV), in the form of an annular disk, whilst in the centre of the annular disk the local resolution detector device 8'' is arranged. In front of the composite radiation source/detector device there is arranged a collimator device 9'' whose laminations 9''a have a conical shape and are arranged one inside another so that gamma radiation is only transmitted which passes through a point-shaped region 10'' (18) situated in the body 6 or originates from said region 10'' (19). The collimator device 9'' is thus focused on the point region 10''. Because of the radiation geometry (in which a large angle is present between the primary and the scatter radiation directions), scatter radiation is detected from a comparatively large part of the focal range of the primary radiation in this apparatus, so that the virtual radiation source can thereby be caused to have a relatively high intensity. This is also applicable to the apparatus shown in Figure 2 if the angle between the gamma radiation beam 17 and the detector device 8' is made either very large or very small. The resolution of the apparatus is not affected, because the extension of the focal range perpendicularly to the radiation direction is comparatively small. Moreover, the effective point region 10'' may be considered to be an isotropic source, because the angular dependency of the scatter radiation is substantially nill for such large or small scatter angles. The body structures 7'' to be examined can be imaged and detected by means of the detector device 8'' on the basis of the scatter radiation (19) originating from the region 10''. The detector device 8'' is adequately shielded from radiation originating directly from the radiation source 14''.

CLAIMS

1. An apparatus for determining the internal structure of a body, comprising at least one radiation source for emitting a primary radiation beam which penetrates the body and which has a substantially point cross-section at at least one location along its path, and at least one detector/collimator device for selectively detecting that radiation which originates from the location of the or a predetermined said point cross-section and which is scattered through a given solid angle in a direction which is different from the primary beam direction, characterized in that the detector device is constructed and arranged to provide a discriminative detection and measurement of scatter radiation extending in different directions within said solid angle, the arrangement being such that a shadowgraph image of internal structures of the body lying between said location and said detector/collimator device can be derived from

the output of said detector device.

2. An apparatus as claimed in Claim 1, characterized in that the radiation source is an X-ray source with a collimator device which limits the radiation in order to form a narrow pencil-beam, the detector/collimator device being arranged to define a focal point at the origin of said solid angle situated on the path of the primary radiation beam.

3. An apparatus as claimed in Claim 1, characterized in that the radiation source is a laminar radioactive radiation source whose radiation which emerges from the surface, is directed towards a point focus by means of a collimator.

4. An apparatus as claimed in Claim 3, characterized in that the laminar active radiation source includes a central aperture for accommmodating the detector device.

5. An apparatus for determining the internal structure of a body, substantially as herein described with reference to any one of Figures 1, 2 and 3 of the accompanying drawing.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1982.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.